The HUDSON RIVER BRIDGE

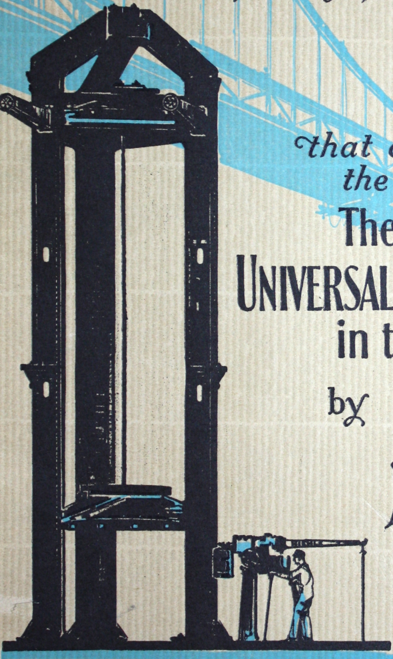
Greatest single-span suspension bridge in the world

that compelled
the creation of

The Largest UNIVERSAL TESTING MACHINE in the World

by

Riehle



THE HUDSON RIVER BRIDGE

Between Upper Manhattan, New York City and Fort Lee, New Jersey. Upon completion this will be the largest single span suspension bridge in the world.

RIEHLÉ BROS.

TESTING MACHINE COMPANY

1424 North Ninth Street
Philadelphia, Pennsylvania

Compliments of
Fred A. Riehle Prest.

Oct. 10th. 1928

foreword

IT was only natural to expect that the design of a suspension bridge of the magnitude of the Hudson River Bridge between upper Manhattan, New York City and Fort Lee, N. J., would produce a host of problems. With 3500 feet intervening between towers, the structure will have a main span suspended over water that will be twice the length of the main span of the Delaware River Bridge, now the suspension bridge with the longest single span in the world. Chief among those who were without precedent to guide them in solving a major problem was the management of the John A. Roebling's Sons Company of Trenton, N. J., the firm that built the cables for the famous Brooklyn Bridge. In the past seventy years they have made most of the wire rope and cables used in suspension bridges erected all over the continent. This experience and data pertaining thereto is their capital, but rich as it is, it included nothing covering a task of this gargantuan size. The problem of chief concern to Roebling's was not that of producing or twisting wire, but that of proving to their own satisfaction what combination was the right one capable of bearing the enormous stresses and strains to be contended with. To test such gigantic cables as must be employed, there was not then in existence, a testing machine of a size sufficient for the purpose. No sooner was the need for such a machine apparent than Roebling's made plans to purchase one capable of exerting the tremendous pull of 2,000,000 lbs. To our organization fell the honor of creating this, the greatest universal testing machine in the world today. In this book we refer to the situation that created the need for this machine, the organization that purchased it, and the machine itself.

The HUDSON RIVER BRIDGE

that compelled the creation of the

WORLD'S GREATEST UNIVERSAL TESTING MACHINE

by Riehlé

FOR some fourteen miles the Island of Manhattan stretches along the Hudson, from The Battery to the Harlem River. To the observer afloat, the New York side presents a view of almost unbroken crags of masonry ranged in serried ranks of streets, sparsely relieved by touches of nature.

On the New Jersey side, Jersey City sprawls northward to meet the famous old port of Hoboken with its background of hills. From here on, Weehawken and other smaller communities meet the gaze, subdued by ever mounting hills until at Fort Lee, opposite upper Manhattan, New York City, the hills take on the precipitous form of The Palisades. Here, early in the War of Independence, the colonists erected a fortification called Fort Constitution, but later renamed Fort Lee, in honor of General Charles Lee. In the vicinity of the fort a village gradually assembled taking the same name.

The natural beauty of the surroundings and their proximity to the ever-growing metropolis of New York early made for frequent passage of the intervening and mighty Hudson. From very early times crude flat boats worked by hand with big sweeps provided ferriage which was badly hampered in winter by ice. With the coming of steam, service was steadily improved and for many years boats of the latest type have been in operation. With the passing of the years, New York spread northward to completely cover Manhattan while the territory back of Fort Lee, and above, into that part of New York State to the northward, spread a vast population dependent upon the city for a livelihood, supplies and amusement.

Approaching New York City from the North on the Hudson, the New York State line halts on the west side, 12 miles above Fort Lee where it meets New Jersey. To the army of commuters and others who go to and from the metropolis, the Fort Lee crossing speedily became a traffic artery of prime importance.

Realizing that the situation at the Fort Lee crossing could never be adequately met by boats, the governments of the States of New York and New Jersey and the authorities of New York City co-operated to provide a bridge.

The width and depth of the Hudson at this point, in addition to the fact that the War Department and port authorities will not permit interference with navigation, imposed great handicaps upon those responsible for the planning of the structure.

However, plans as submitted to the United States District Engineer, First District, and the Secretary of War, in December 1926 won speedy approval. This promptness was probably induced by reason of the fact that the bridge will have a clear height of 195 feet above mean high water at the towers and 213 feet at the center. This clearance compares as follows with other bridges across waterways capable of carrying ocean-going craft of the largest type:—the five East River Bridges in New York have 135 feet clearance at center, the Delaware River Bridge at Philadelphia, 135 feet; the St. Lawrence Bridge at Quebec, 150 feet, and the bridge at Sydney Harbor, Australia, 170 feet. The Hudson River Bridge will therefore exceed by 25 feet the clearance under any bridge over waterways carrying the largest vessels.

A fair conception of the size and proportions of the Hudson River Bridge may be formed by a comparison of its leading features with those of the Delaware River Bridge, at present bearing the longest single suspension span in existence.

The Delaware River Bridge has a single span of 1750 feet while the Hudson River Bridge will have a span of 3500 feet—just twice as long as the present world's greatest bridge.

The towers of the Delaware River Bridge are 380 feet above water—those of the Hudson River Bridge 635 feet.

Weight of the suspended structure of the Hudson River Bridge is 90,000 tons compared to 40,000 tons on the Delaware Bridge. Strength of carrying cables on the Hudson River Bridge will be 350,000 tons in comparison to the 120,000 tons on the Delaware River Bridge cables.

An interesting feature of the Hudson River Bridge is the floor structure which is divided into two decks. The upper will be used exclusively for vehicular and pedestrian traffic while the lower will be reserved for rapid transit traffic. However, the lower deck will not be added until traffic warrants, possibly within ten years.

It is estimated that the traffic capacity of the bridge will be 30 million vehicles per year, but not more than 20 millions are anticipated.

The task of supplying the wires and cables upon which to suspend this great bridge was awarded to John A. Roebling's Sons Company of Trenton, N. J. It was this company that built the cables for the

famous Brooklyn Bridge which for many years held the distinction of being the greatest suspension bridge in the world. When the problem was approached by the Roebling engineering staff it was soon recognized that the past as a measuring stick would have to be disregarded in view of the length and size of the span and the great weight to be carried in suspension.

During the many decades the Roebling organization have been building cables for suspension bridges of varying size they had accumulated data pertaining to the carrying qualities of their products, but none relative to a piece of engineering of this magnitude. It was an easy matter to experiment with various twists and combinations of wire, but there was not in existence apparatus capable of testing cables of the diameter and strength required.

To meet the situation, the management decided that, "one test was worth a thousand expert opinions." To make it possible to conduct tests of the mighty cables required, it was planned to obtain a testing machine capable of testing wire cables for tensile strength up to 2,000,000 lbs. or 1000 tons.

To the Riehlé organization fell the honor of creating the giant testing machine required by Roeblings. While in the main, the machine produced adhers to the lines of Riehlé Universal Testing Machines that are fully covered by patents, however it is unique in so many respects that it really represents something entirely new in the development of large-capacity testing machinery.

Up to the time of the construction of this giant machine for Roebling's, the largest universal testing machines in existence had a maximum capacity not in excess of 1,000,000 lbs. each. Of these more than a half dozen have been constructed for schools and organizations in different parts of the country by Riehlé.

The machine supplied to Roebling's order is known as the Riehlé 3 Rotating Reversed Screw Universal Testing Machine. It is of screw power design and created primarily to test large wire cables for tensile strength. However, with the use of suitable tools and attachments it can readily and quickly be adapted for transverse and compression tests.

To clarify description, the machine is hereinafter discussed in two divisions: the straining or loading section and the weighing system. Each performs a separate and distinct function, as the name indicates. Where key figures are given, refer to the illustration on the page mentioned.

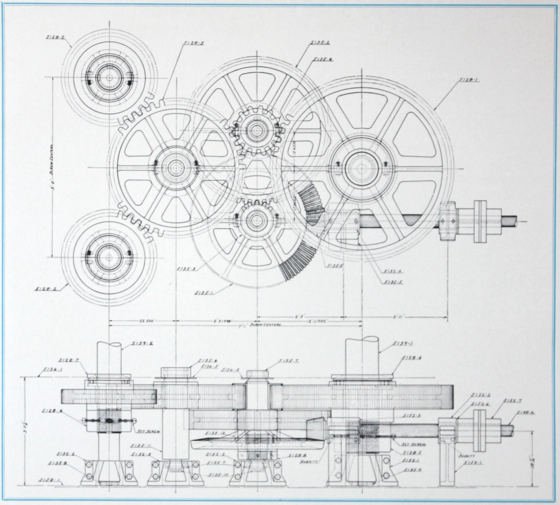


Fig. I

The GIANT RIEHLÉ UNIVERSAL TESTING MACHINE

SECTION I

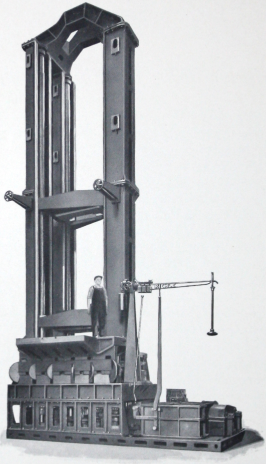
Description of the straining or loading section

A VERY essential part of the straining mechanism is the upper or stationary head which is held in position by pins or keys passing through slots in the columns. Referring to Figure II on page nine, which is a drawing of the front elevation of the machine, it will be seen that there are three sets of these slots, thus giving the operator the choice of three different positions of the upper head. The operation of changing the position of the head is greatly facilitated by a device, shown in position, which withdraws or forces in the key by means of a screw and handwheel. The adjustable head is raised or lowered to the desired position by the moving head, while the keys and their respective operating apparatus are handled by the crane which serves the machine.

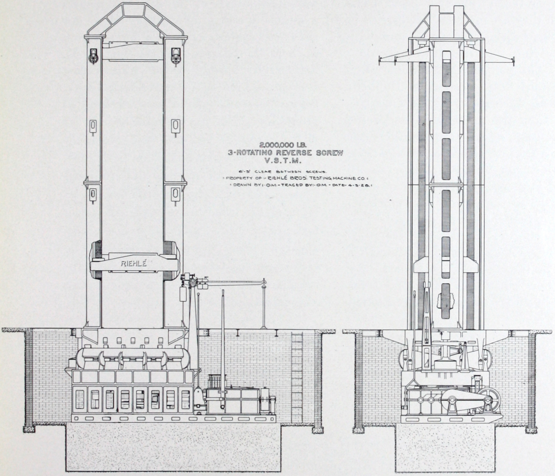
The pulling head is moved up or down as desired by three pulling screws turning in manganese bronze nuts forced into the head and held in place by keys and lock-nuts.

The two heads are massive steel castings, 24″ thick and weighing nearly 25,000 lbs. each. They are pierced by rectangular cored slots to permit the specimen to pass through, while the lower surface of the pulling head and the upper surface of the fixed head have machined tee-slots to permit the attachment of suitable tools or fixtures for various types of specimens. Owing to the special nature of the work to be done the customary wedge grips are not employed in this particular design.

There are three pulling screws, one of which is 11½″ in diameter, 38′4⅝″ long and weighing 13,620 lbs. This screw sustains a load of 1,000,000 lbs. at full capacity. The other two are 8½″ in diameter of the same length as the front screw and weighing 7,470 lbs. each. They sustain a load of 500,000 lbs. each at full capacity. The use of three screws insures complete stability of the pulling head and also a uniformly proportionate loading of each screw. The reversed screw principle, a Riehlé patented feature, is employed so that the rotative effect on the head resulting from friction of the screws turning in the nuts is practically neutralized.



Actual photograph of 2,000,000 lb. Machine after assembly on Shop Floor


2,000,000 LB.
3-ROTATING REVERSE SCREW
V.S.T.M.
6'-5' CLEAR BETWEEN SCREWS.
PROPERTY OF RIEHLÉ BROS. TESTING MACHINE CO.
DRAWN BY: O.M. - TRACED BY: O.M. - DATE 4-5-26.
RIEHLÉ

.G. II

The screws are rotated by a train of gears of rugged design shown in assembly in Figure I on page six. These are all steel castings or forgings and with ample strength to sustain the heavy loads placed upon them. The spindles or shafts on which they are mounted are carried in radial roller bearings top and bottom with thrust bearings underneath to carry their weight. The pull of the screws is taken on large roller thrust bearings with spherically seated washers for self-alignment.

Passing from the main gears under the table, we come next to the speed change gears and friction clutch assembly (Figure III) on page thirteen. These are all mounted in a cast-iron box as a separate unit bolted to the base of the machine. A selective gear change is a unique feature of this portion of the design. Four different pulling speeds may be obtained as desired, by throwing a single lever to any one of four positions. A second lever serves to operate the clutch for starting the machine in either direction or for stopping. The gearing is continuously flooded with oil and a central sight feed oiling system is provided for all bearings. A rotary geared pump delivering to a tank mounted outside of the gear-box insures a constant and ample supply of oil for the entire system. Power is derived from a 75 H. P. Reliance 800-1600 R. P. M. Adjustable Speed Motor transmitting through a Link-Belt Silent Chain Drive, fully enclosed and with an individual pump for delivering a constant flow of oil to the chain. The electrical equipment is of the remote control type with push button station for starting and stopping. Close speed regulation is obtained by an interpolating rheostat for field control, a tachometer being used to indicate any departure from the correct speed. The tachometer and electrical control equipment are all mounted on a panel board conveniently located.

The GIANT RIEHLÉ UNIVERSAL TESTING MACHINE

SECTION II

Description of the weighing system

WHILE the loading or straining system is necessarily of a very heavy and rugged construction throughout, it is, however, in the weighing system that we find the heaviest and most massive parts. Of these the table is the most prominent and impressive. This is a one-piece steel casting 13′0″ long by 11′1″ wide on its upper surface and weighing 48,850 lbs. At full capacity, it sustains the total load of 2,000,000 lbs. which it in turn transmits to the lever system on hardened steel knife edges. These are designed for a unit load of 10,000 lbs. per linear inch so that the total length of knife edge is in excess of 200 inches.

The lever system in itself presents many novel features of design as may be seen by reference to Figure IV on page thirteen. Two primary main levers, identical in size and form are mounted on opposite sides of the machine with their noses turned toward the centre, each carrying the tremendous load of 1,000,000 lbs. A fraction of this is transmitted to a pair of secondary intermediate levers by which, now reduced to 1,000 lbs., it is transmitted to the weighing beam.

All the knife edges are of high-grade tool-steel, hardened and ground to size. Eleven different samples of tool-steel were machined to shape, heat treated and tested before a final selection was made. The main levers are supported on a very rigid and heavy steel casting known as the coverplate. This piece, which weighs over 41,000 lbs., is one of the most vital parts of the machine and performs many important duties. In addition to providing support for all the weighing levers, it absorbs the pull from the screws, houses the main bearings for the screws and the upper bearings for the gearing below it and also affords an anchorage for the recoil apparatus which takes the heavy shocks occurring when specimens break under large loads.

This recoil apparatus, a new design, is of the hydraulic type. It is entirely automatic and in no way affects the ac-

curacy or sensitiveness of the beam. The load is weighed on a beam of the conventional type on which the poise is moved by a screw operated through a train of gears by a hand wheel. The screw carries a micrometer dial for reading small increments of load. The only unusual feature is the use of three separable poises by which it is possible to indicate fractional readings of 1/4 and 1/2 as well as full capacity. The entire machine weighs about 275,000 lbs. and is 42′10¾″ high. Its extreme width is 13′ and its length 21′.

The maximum length of specimen which can be tested is 25′ while the clear space of 75″ between the screws provides ample room for large pieces.

The capacity of this machine is sufficient to pull apart a bar of structural steel nearly 6″ square or to crush a cast-iron column 15″ in diameter, 15′ long with 1¼″ walls.

At full motor speed the pulling head may be operated at speeds of—10″, 2″, .5″ .1″ per minute while at slow motor speed pulling speeds of—5″, 1″, .25″, .05″ per minute are available.

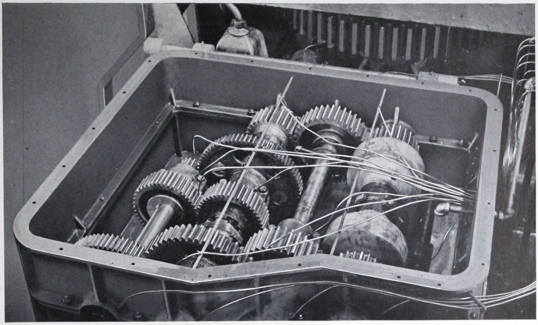


Fig. III

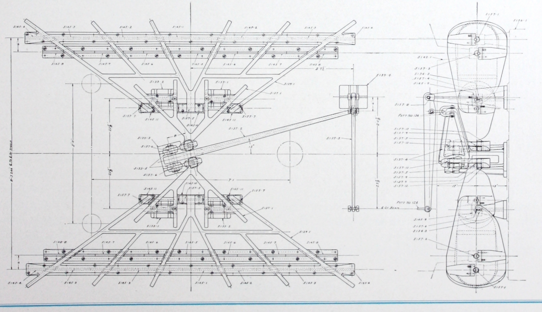


Fig. IV

The ORIGIN *of the* TESTING *of* MATERIALS

TODAY there are few manufacturers so disinterested in the performance of their products that they refuse to conduct experiments to learn what the ultimate limit of endurance may be. Makers of fan belts devise ways to subject them to what would be months of wear in hours. Makers of fabrics give them a year's washings in a short time. Steel, lumber, cement, brick and special material makers pile loads upon their commodities in an endeavor to learn what weights they will carry, what strains they will resist. Makers of such widely different things as razor blades and rubber ties vie with one another to discover the life of what they create. Engineers and architects, specialists in every line, draw specifications stipulating generous factors of safety. To meet these requirements, those who supply what is wanted have no alternative but to test. Governmental standards rest upon tests. Legislation in many places makes the practice mandatory. Yet, what is now standard practice, what is universally accepted as correct, is of relatively recent origin.

While this organization can lay no claims to being the first to conduct tests, man himself having been continuously engaged in the practice since Adam speculated upon the effect of the apple upon the human constitution, it is believed that the Riehlé organization can safely lay claims to being the pioneer builder of scientific testing machines as they are known today.

In 1866, Riehlé Brothers was considered an old Philadelphia firm making scales of every description. At that time the business was forty-one (41) years old, having been in existence since 1825. To the plant one day in 1866, came a manufacturer from Conshohocken, Pa., who made cast iron pipe. He explained that he had a contract for supplying large quantities of cast iron pipe for use by the city of Boston. The contractor doing the work reported that the pipe was breaking in transit, during handling, or after short use.

In view of this performance, the City of Boston was withholding payment due the contractor, claiming inferior quality, necessitating a suit by both parties. So far, the pipe maker complained, all testimony was based upon the opinions of so called experts. No one seemed to be in possession of any real facts as to what cast iron pipe could or could not do. The manufacturer ended his story by insisting that Riehlé Brothers build him a device that would furnish something more tangible about his products than mere opinions. It was not long, however, before the pipe manufacturer returned, bringing specimens of the pig iron he was using. The management of the Riehlé works turned aside for the moment from scales and

concentrated upon the creation of a device or a method that would break pig iron and at the same time register the load under which it broke.

In a short while a cumbersome piece of apparatus with rugged uprights and crossbeams took form, similar to that shown in Fig. V. Tests showed that it could subject materials to various stresses up to 20,000 lbs. To this device was entrusted a piece of iron about the size of a spool of wool, very short and with a 1-inch breaking area. Weights were slowly and laboriously added, but finally the specimen broke, the load registered, and a certificate of record issued. The maker of cast iron pipe bought it for evidence and later on it was instrumental in helping both the manufacturer and the contractor to win their suits with the City of Boston.

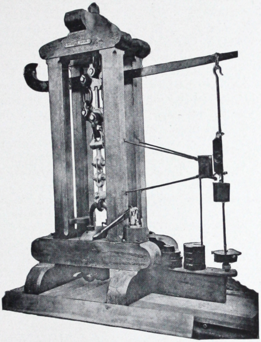


Fig. V

When the news of this new device spread through the pipe industry, every manufacturer wanted one. To the business of making scales was suddenly added that of making the first testing machines in America, if not the world.

The business of making testing machines increased steadily in volume and when an opportunity to dispose of the scale works presented, Riehlé Brothers sold out that division of operations and concentrated on testing machines.

In 1870 the plant was busily at work producing testing machines with wooden frames for a wide variety of uses when the United States Government induced a radical step by proffering a contract for ten machines, provided they were constructed entirely of metal. These machines were for the purpose of testing boiler plate. After seven years of experiment, the government made it compulsory to test all boiler plate and this induced a great number of orders from that industry, including the famous old Carnegie Steel Works.

Shortly afterward the Riehlé works started to develop what is known today as the universal testing machine; a machine capable of testing not only for tensile and compression strength, but transverse, too. Upon the completion of this epochal step, Industrial America seemed to form in line as favoring testing and one industry after another came to Riehlé to obtain ma-

chines suitable for their respective lines. As the universities and technical schools had been early advocates of material testing they soon entered the market for Riehlé devices. Today, testing machines are practically standard equipment in most of them. In the early 80's however, the vogue was just starting with the result the Riehlé works was the Mecca and meeting place for many men who have won distinguished place in many walks of life. Admiral Schley, of Spanish-American War fame, was one of the early visitors who placed an order for a machine so unique he came to supervise its construction. Mr. John Fritz, of Bethlehem, Pa., the first man to introduce steel rails to America, was another.

Up to 1890 all testing machines were hand driven or belt driven from a line shaft. About that time a prospective customer, located far from sources of steam power, wanted a machine too big to work by hand. Although electricity was then more or less in the experimental stage, motor drive was suggested. Its success made Riehlé a pioneer in this form of operation. With the formation in 1898 of the American Society for Testing Materials, an embryo industry began to take definite form. Out of a perplexing mass of data, laws, standards, codes and theories was evolved a single set of proven standards. This necessitated the redesign of testing machines and marked a milestone for the infant industry, and industry in general. With the adoption of standards, progress did not cease. With the dawn of the 20th century not only did new lines of endeavor enter the testing arena, but specimens grew larger and heavier, calling for more powerful machines. Who knows but that in the future it may be possible to test whole arches and whole bridge sections, as easily as such minute things as needles and slivers of materials. There are now in existence testing machines that can handle specimens weighing but a fraction of an ounce and the Giant Riehlé Universal Testing Machine built for Roeblings that is capable of subjecting wire cables and other materials to the enormous pull or pressure of 2,000,000 lbs.

Not alone is the present age notable for the extremes of weight handled, but for variety of uses as well. The Riehlé organization has built machines to test the adhesive power of tape used in medical circles, machines to show the deformation of golf balls under various driving tests, machines to test enamel plates, the muscular reaction of a frog's leg, the strength of battleship anchor chain, buttonholes, handles of caskets and the tractive power of elephants.

In reviewing the unfolding of the testing machine from its crude stages a few decades back, to the perfection of the huge universal types of today, there is a story of interest not only to the engineer and man of business but the layman as well. The sure footed progress of Industrial America and its rise to power as a world force may be said to be based upon the fact that its leaders have ever been willing to concede that *"one test is worth a thousand expert opinions."*

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